



Next Generation Internet Technology

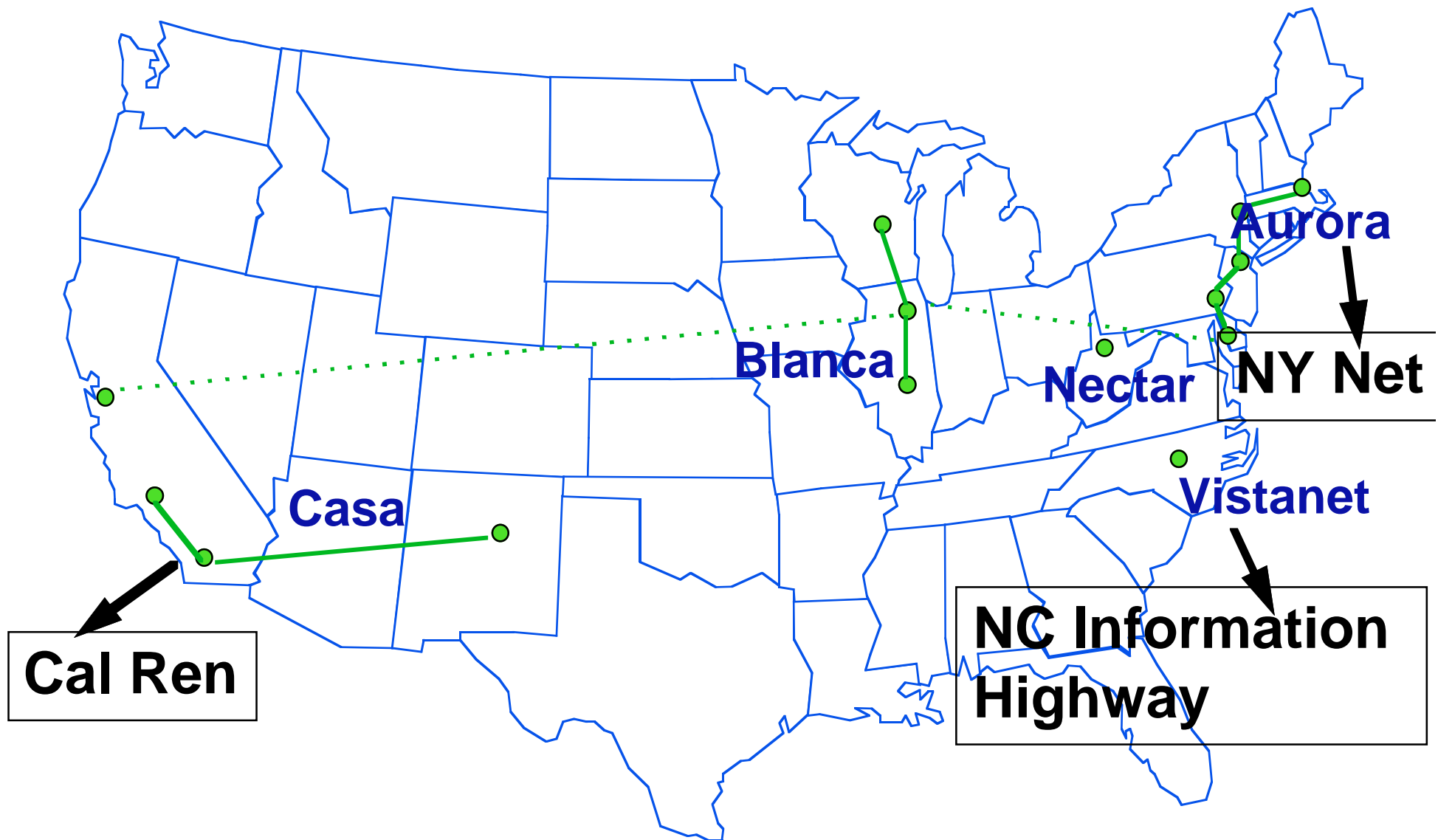
**Presented to
The Internet Caucus**

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DARPA/NSF Gigabit Testbeds Led ATDNet and Commercial Technology





Government Impact on Networking



- **ARPANET (packet switching): 1970s**
- **Internet technologies- Transparent network interconnect, addressing & routing, TCP/IP: 1970s- 1980s**
- **LAN, Packet Radio, and Cellular systems: 1970s- 1980s**
- **Optical Wave Division Multiplexing: 1990s**
- **Gigabit Testbeds: 1990s**
- **ATM technology, ATM and SONET prototype network: 1990s**
- **High Performance Internet Protocols (RSVP, ST2, IPv6, IPSEC, MobileIP, multicast): 1990s**
- **Browsers and WWW: 1990s**
- **MBONE (conferencing virtual multicast backbone): 1990s**



Government Network Technology

From \$0 to multi-billion \$ Industries



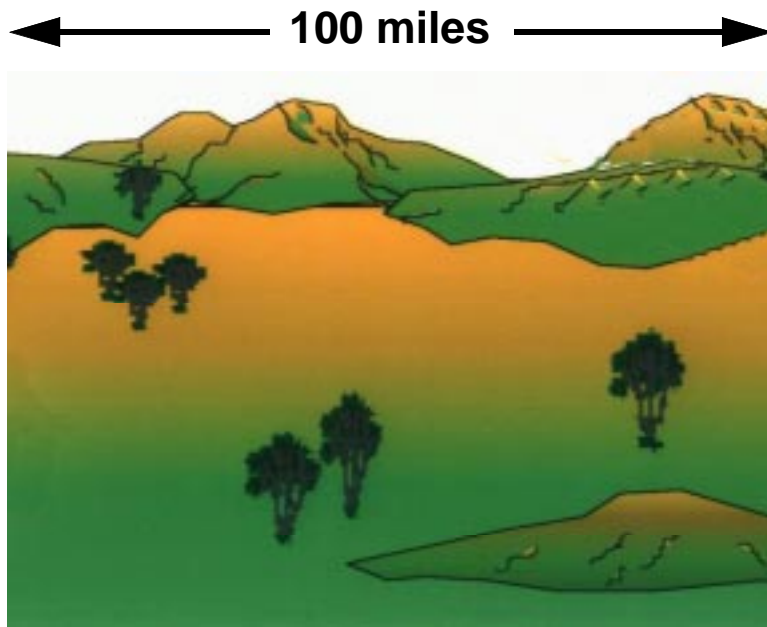
- Packet Switching launched by **ARPANet** in 1969-70.
- **Telenet** founded by **BBN** 1975-76. Acquired by **GTE** in 1980.
- **NSFNet** mid 1980s.
- **CISCO Systems** founded in 1984 by Stanford professors.
- Regional networks developed including **FARNet**, **PLANet**, **UUNet** (now a major ISP).
- Mosaic and World Wide Web transform Internet from research vehicle to international phenomenon. **Netscape** founded.
- **Cisco** has over \$4B in revenue and \$40 billion stock market value 1996.

- **DARPA** studies in 1970s and industry research in 1980s show feasibility of Asynchronous Transfer Mode (ATM).
- **DARPA/NSF** gigabit testbeds launched in 1990. Telco participation includes **AT&T**, **MCI**, **Sprint** and **RBOCs**. Telcos construct high speed SONET systems for testbeds.
- **Fore Systems** founded by CMU professors in 1990.
- ATDNet, first procurement of high speed ATM//SONET, provides early market and technology proof by **Bell Atlantic**, **Fore Systems**, **Bellcore**.
- DISN Leading Edge Prototype Network stood up by **DISA** in 1995/96.
- **Fore Systems** has \$400M in revenue and over \$4B stock market valuation 1996.

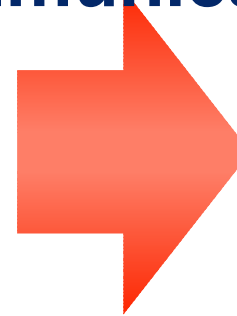
Where do we go from here?



Government Applications Require Huge Bandwidths



**DoD Information Superiority
requires Terabit Battlefield
Communications**



(1 ft x 10 bits)

2.8 Terabit

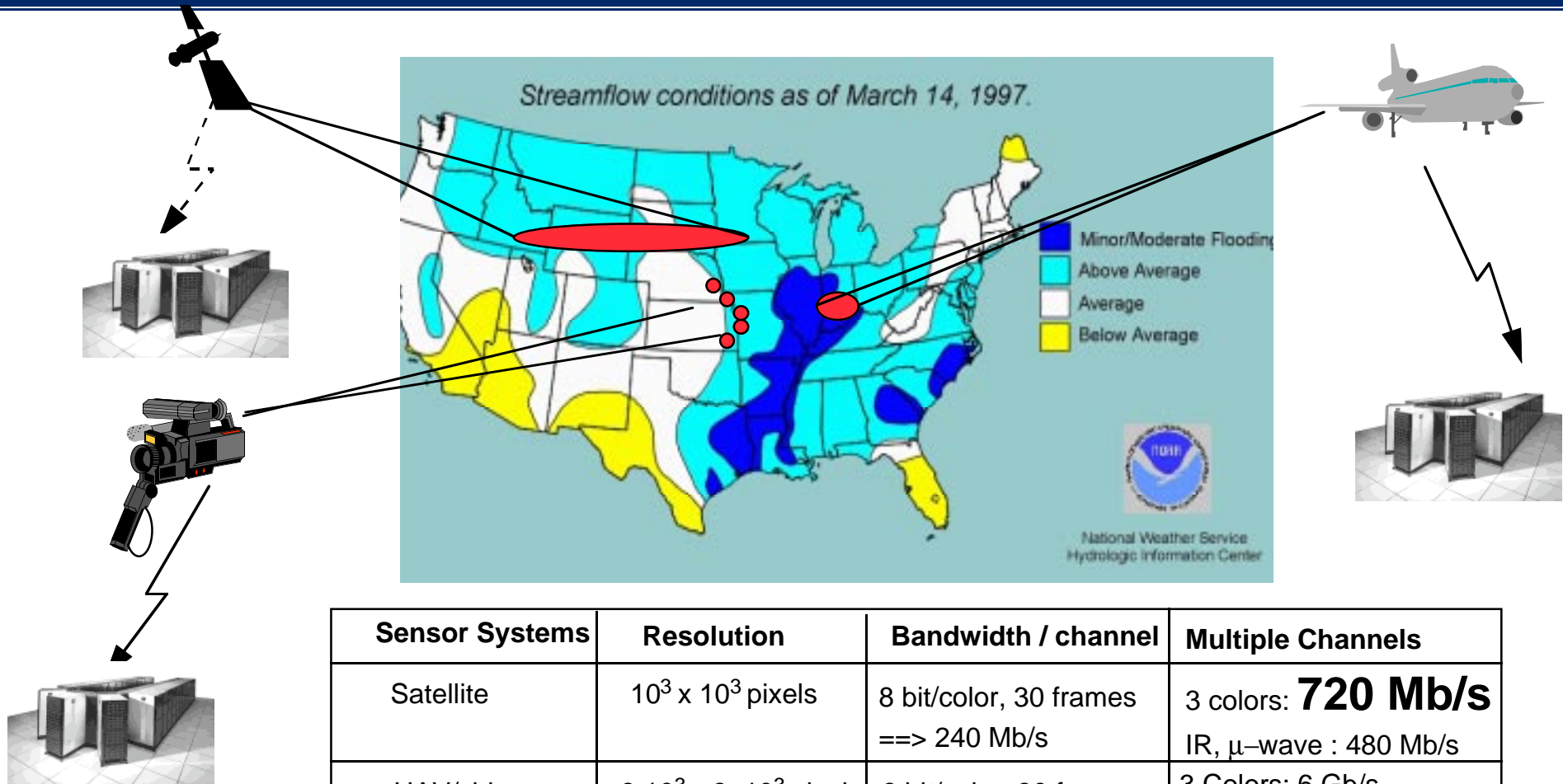
<u>Communication Rate</u>	<u>Time for 2.8 Terabit</u>
(T3 - 45 Mbps)	25 hours
(OC48 - 2.5 Gbps)	15 minutes
(Tbps)	2.8 seconds

Other Traffic Sources

- Radar/SAR
- Multi-spectral sensors
 - Infrared
 - μ -wave
 - RF



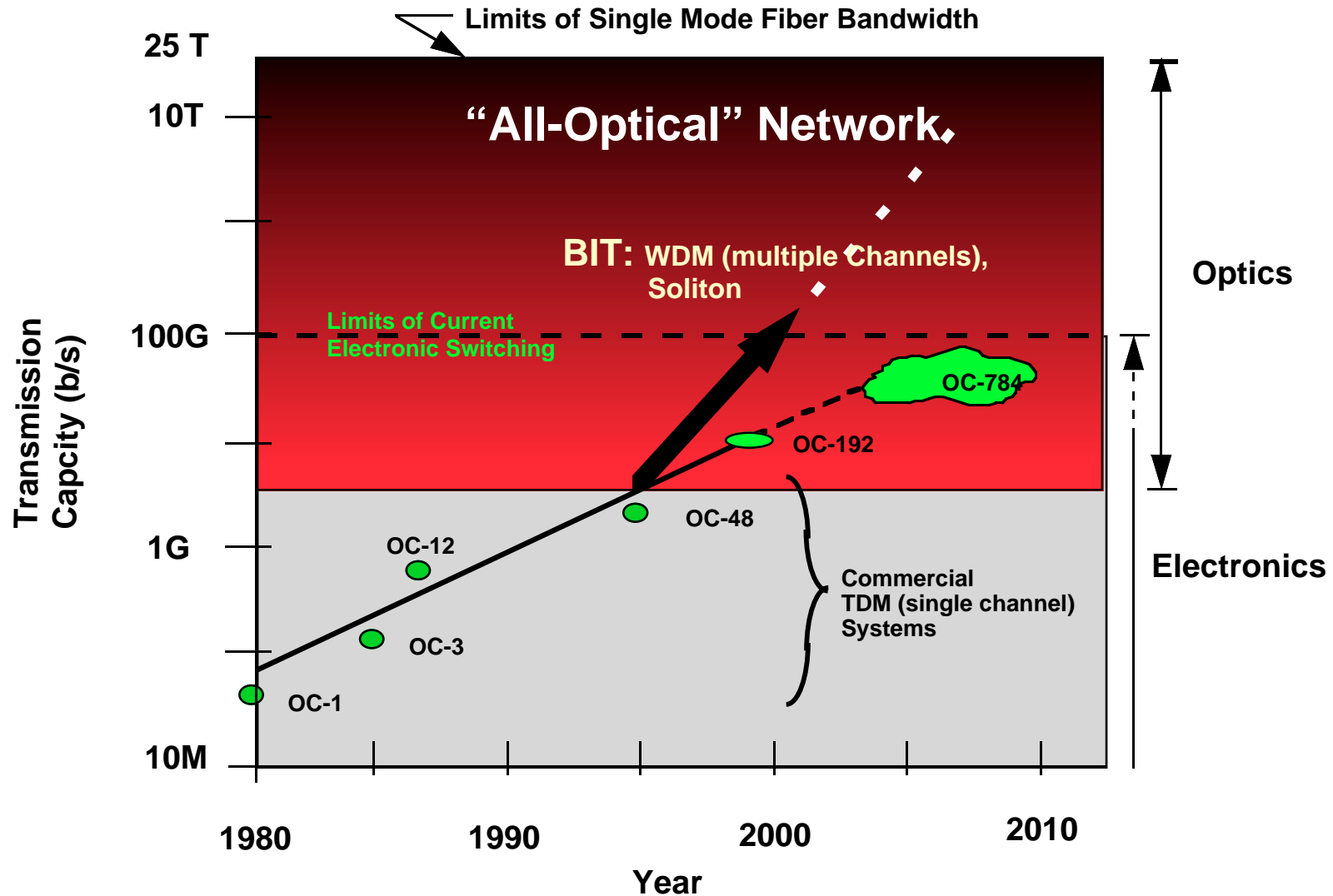
Crisis Management requires Gigabits



Sensor Systems	Resolution	Bandwidth / channel	Multiple Channels
Satellite	$10^3 \times 10^3$ pixels	8 bit/color, 30 frames ==> 240 Mb/s	3 colors: 720 Mb/s IR, μ -wave : 480 Mb/s
UAV/video	$3 \cdot 10^3 \times 3 \cdot 10^3$ pixels	8 bit/color, 30 frames ==> 2 Gb/s	3 Colors: 6 Gb/s IR, μ -wave : 4 Gb/s
radar	1 Ghz bandwidth	Nyquist, dynamic range ==> 20 Gb/s	20 Gb/s
Cellular	100 Mhz bandwidth	2 Gb/s	5 bands ==> 10 Gb/s



Tomorrow's Revolutionary Technologies can lead to affordable Gigabits



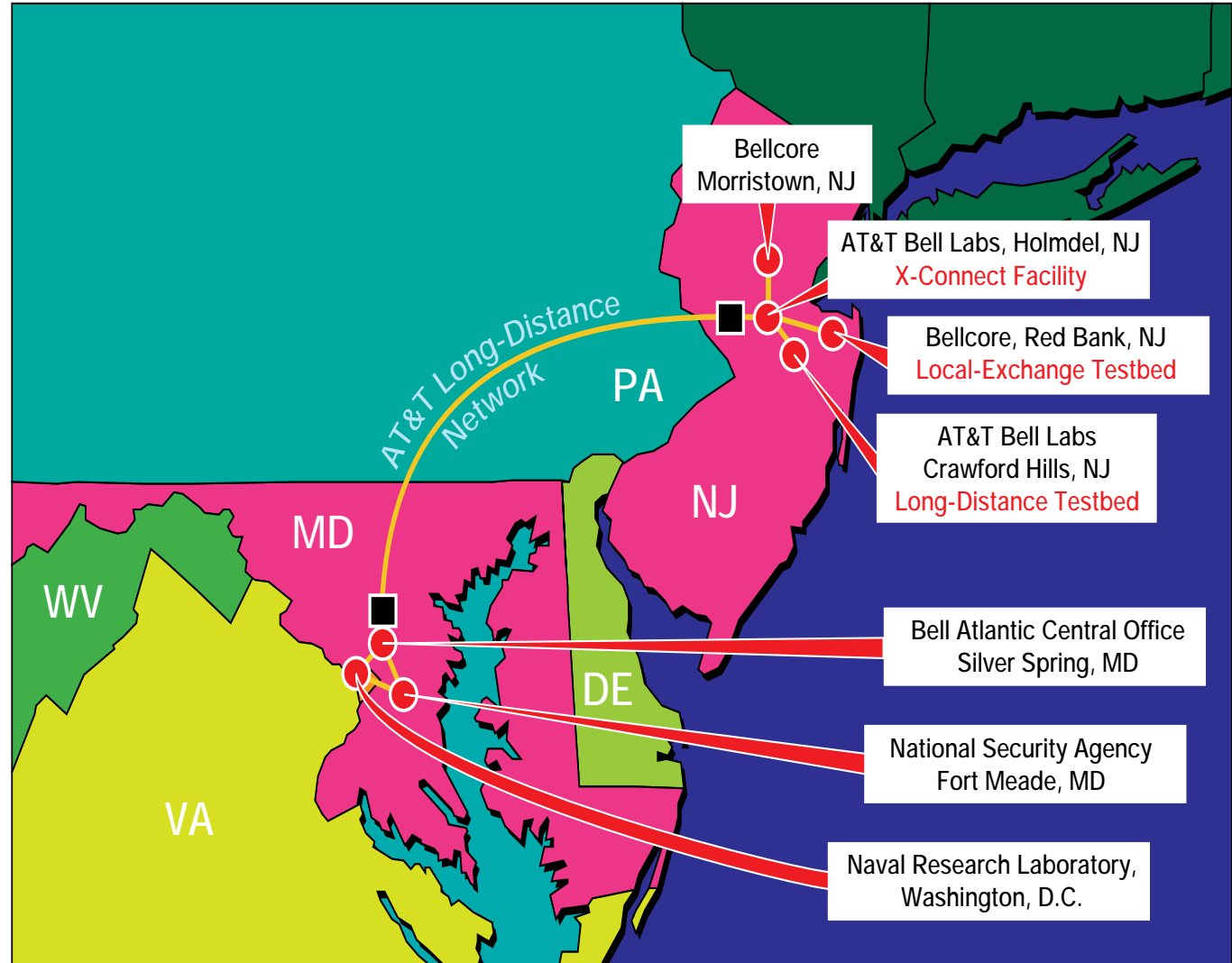


DARPA Broadband Information Technology Program



Representative Testbed & Field Demonstration

■ Optical Research Contractors:
AT&T, Bellcore, Bell South, Columbia Univ, DEC, Georgia Tech, GTE, Hughes, IBM, MIT-LL, MIT, NorTel, Rockwell, Stanford U, Univ. Mass, UTRC





DARPA Broadband Information Technology Program



- **Develop the all-optical wavelength- division multiplexing (WDM) technologies necessary to achieve four new physical layer networking services**
 - **gigabit per second bandwidth on demand**
 - **rapid, nearly transparent reconfiguration of network routing at the physical layer**
 - **multiplexing of continuous transmission rates from kbps to Gbps**
 - **transmission of analog and digital signals in a single fiber**



NGI Ultra High Speed Technologies

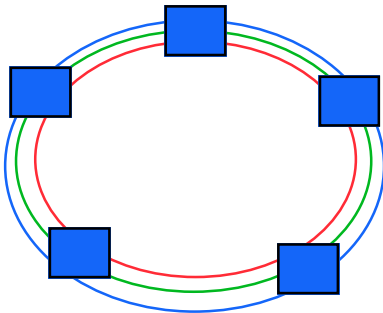


DARPA BIT Program

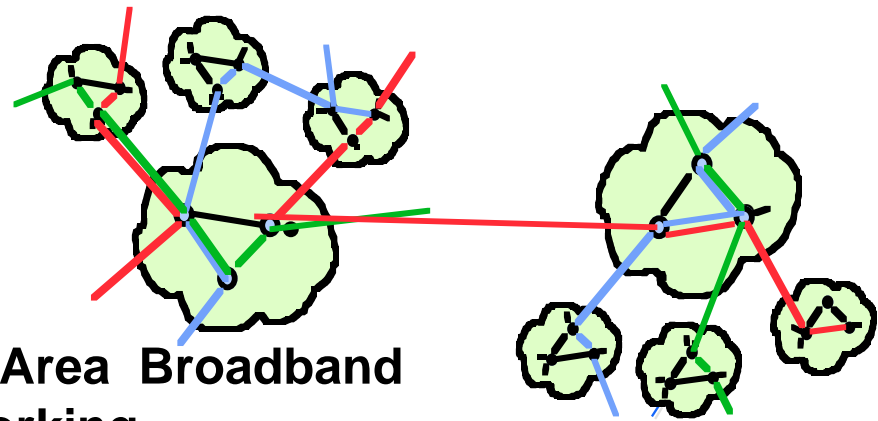
Point-to-Point Transport



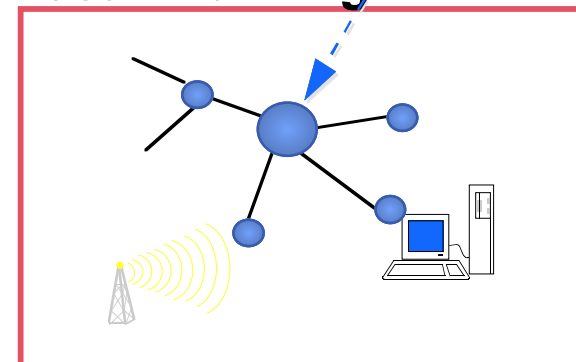
WDM Ring with Add/Drop



NGI Task 1.2



- Wide Area Broadband Networking
- Tb/s Multiplexing and Switching
- Broadband Local Trunking
- Field Trials

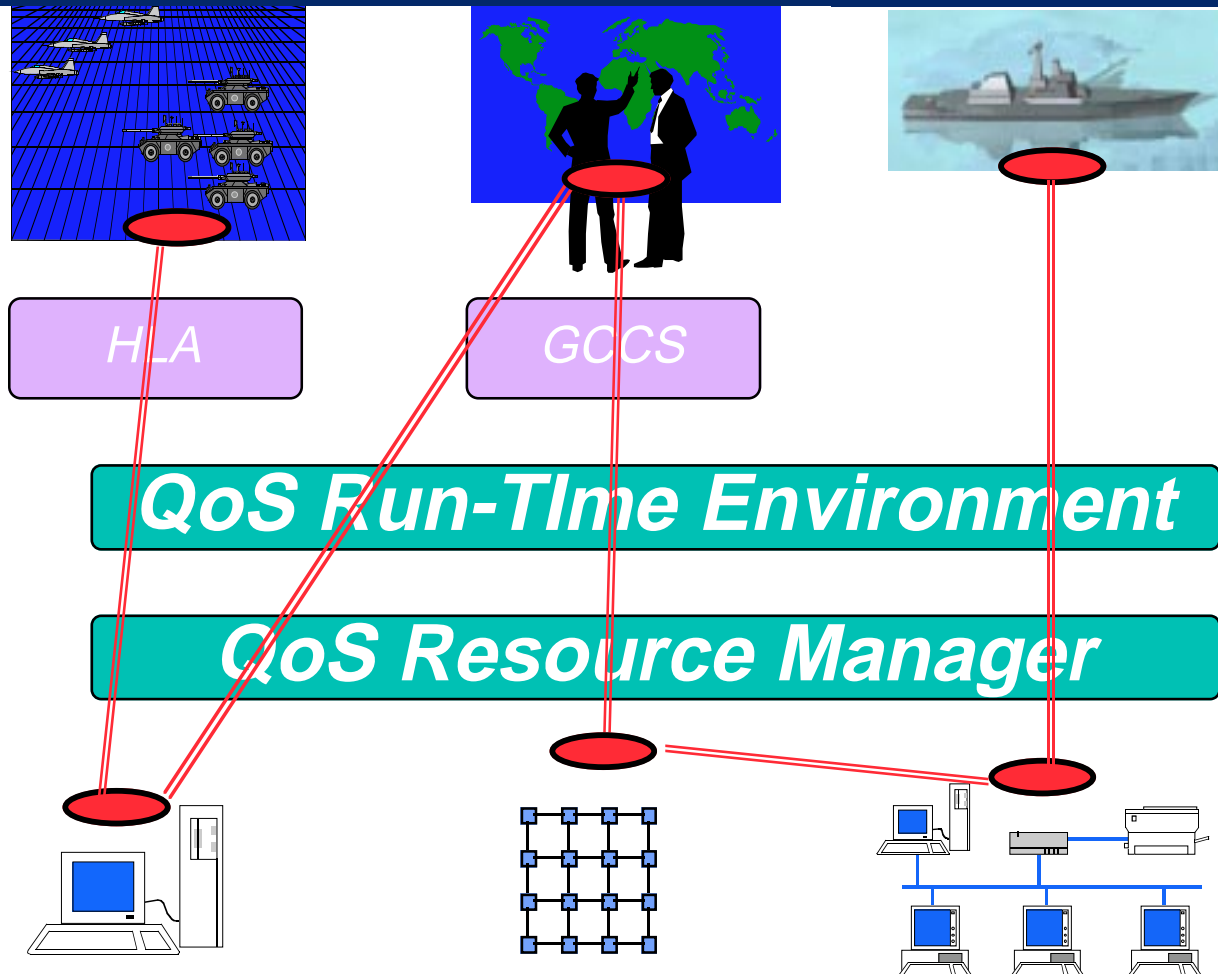




Quality of Service (QoS) Guarantees



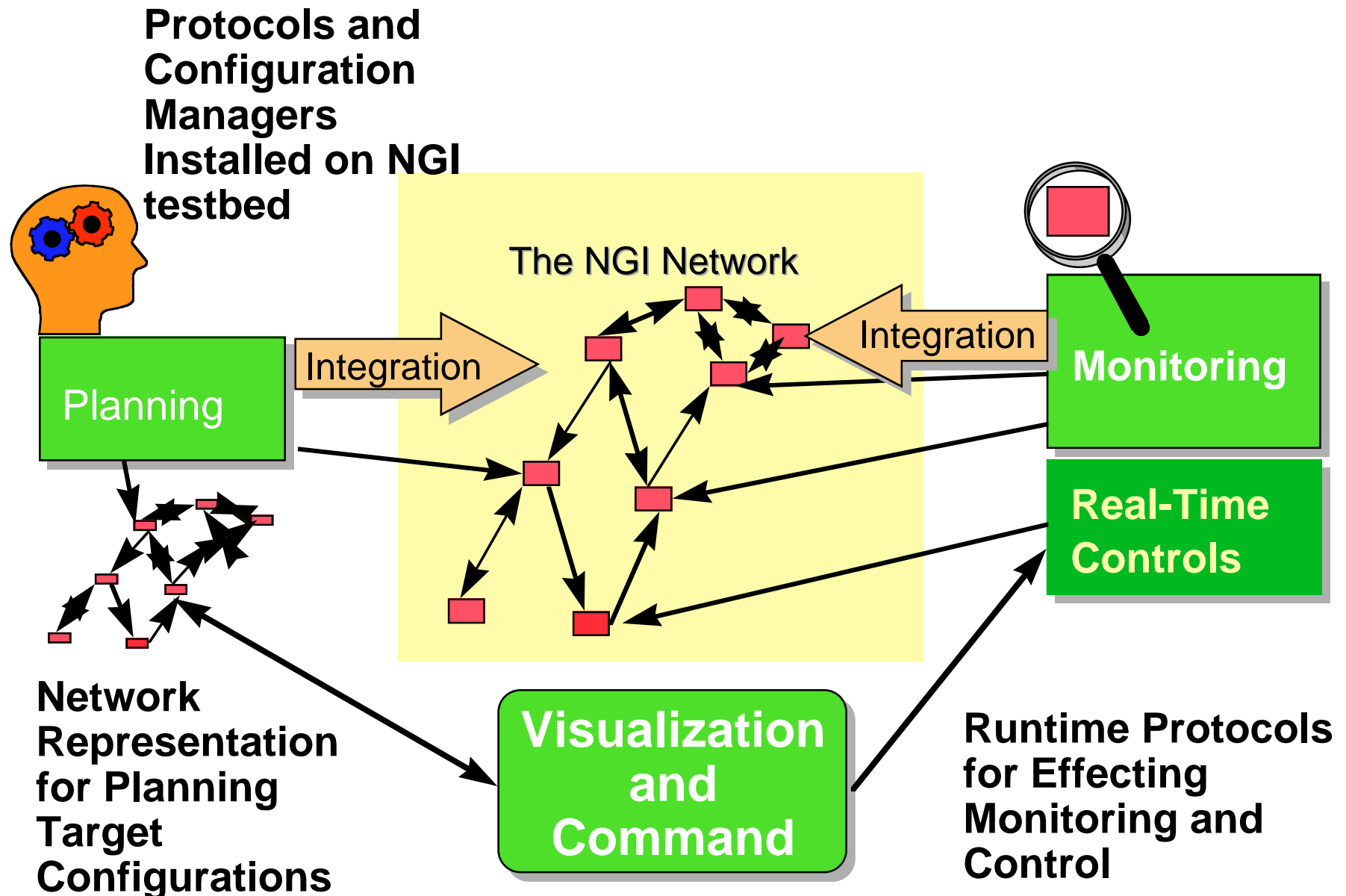
Modeling & Simulation *Command & Control* *Embedded Weapons*



- Assured response with Negotiated QoS
- End-to-end guarantees
- Adaptable, survivable
- Seamless Environment
- Dynamic customized execution
- Integrated middleware/OS/network paths
- Shared data and resources
- Marshaling resources as-needed

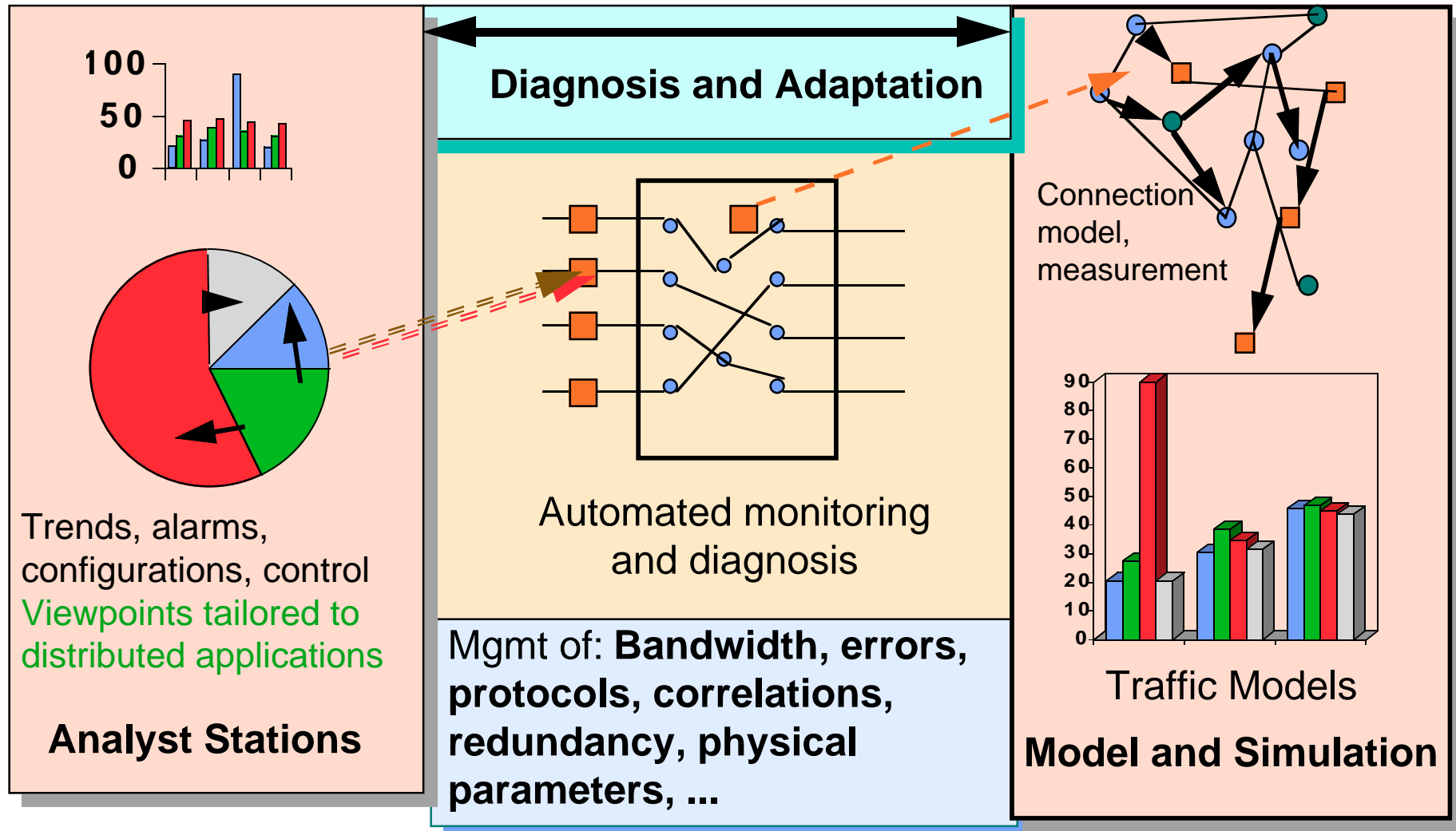


NGI Research in Protocols and Network Management





NGI Advanced Network Management





NGI: A New Stake in the Ground



Capacity
Coverage
Cost
Performance

